

1025:1 Area Ratio Nozzle Evaluated at High Combustion Chamber Pressure

High-area-ratio nozzle on test stand.

A recently completed experimental test program obtained performance data on an optimally contoured nozzle with an exit-to-throat area ratio of 1025:1 and on a truncated version of this nozzle with an area ratio of 440:1. The nozzles were tested with gaseous hydrogen and liquid oxygen propellants at combustion chamber pressures of 12.4 to 16.5 mPa (1800 to 2400 psia). Testing was conducted in the altitude test capsule at the NASA Lewis Research Center's Rocket Engine Test Facility (RETF), and results were compared with analytical performance predictions. This testing builds on previous work with this nozzle at Lewis, where testing was completed at a nominal chamber pressure of 350 psia.

High-area-ratio nozzles have long been sought as a means to increase the performance of space-based rocket engines. However, as the area ratio increases, the physical size and weight of the nozzle also increase. As a result, engine and vehicle designers must make tradeoffs between nozzle size and performance enhancement. Until this test program, very little experimental data existed on the performance of the high-area-ratio nozzles used in rocket engine designs. The computer codes being used by rocket engine designers rely on data extrapolated from tests of low-area-ratio nozzles, and these extrapolations do not always provide the accuracy needed for a reliable design assessment. Therefore, we conducted this high-area-ratio nozzle testing program to provide performance data for use in rocket engine design and analysis computer codes.

The nozzle had a nominal 2.54-cm- (1-in.-) diameter throat, an exit diameter of 81.3-cm (32.0-in.) at an exit-to-throat area ratio of 1025, and a length of 128.6 cm (50.6 in.). Testing was conducted in an altitude test capsule to simulate the static pressure at altitude by vacuum pumping. Data such as propellant mass flow, oxidizer-to-fuel mixture, and thrust were measured. These measurements were then used to calculate performance factors such as the thrust coefficient, the characteristic exhaust velocity efficiency, and the vacuum specific impulse. In addition, the nozzle temperature was measured to calculate the amount of heat transferred from the combustion gases to the nozzle.

References

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